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BULLETIN No. 126.

SOILS.

1. METHODS AND USES OF SOIL ANALYSIS.
2. ANALYSES OF SOILS IN 1904 AND 1905.
3. ON THE DETERMINATION OF HUMUS IN SOILS.

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BULLETIN No. 126.

SOILS.

BY A. M. PETER AND S. D. AVERITT.

1. METHODS AND USES OF SOIL ANALYSIS.

In the earlier days of agricultural chemistry it was the common practice in soil analysis to act upon the soil with a strong acid, such as hydrochloric acid of specific gravity 1.115 and determine what substances were dissolved by this medium and how much sand remained undissolved. It is possible, from such an analysis, to say whether a given soil contains much or little of the mineral elements that are essential to plant growth, such as phosphorus, potassium, calcium, &c., but the action of a strong acid upon a soil brings into solution compounds that are incapable of yielding up to plants any appreciable amount of their valuable constituents under field conditions. The action of strong acids upon the soil goes too far to be of much value as an indication of what the plant can abstract from the soil for use in its growth. Such analyses are of use in classifying soils and also to show us what store of phosphorus, potassium, calcium, &c., there may be in the soil, but they give us very little idea as to whether crops can make use of this store. True, as regards phosphorus, it was generally found that an appreciable portion of the phosphorus shown by such an analysis, say from 1-100 in the lower percentages to 1/3 in the highest, is available to crops or can be made so by proper tillage, so that a soil which shows about .05 per cent. of phosphorus pentoxide (commonly called "phosphoric acid" in statements of analyses) or less, is recog-

nized as deficient in phosphorus and surely to be benefited by the application of phosphates. With potassium the case is still more difficult, because the analyses generally show several tenths of a per cent. of potassium oxide (commonly called "potash" in the statements of analyses) even when crops on the soil fail unless potassium salts are applied. A striking instance of this kind was found in the soil of the old farm of this Station, as shown by field experiments described in our earlier bulletins. These difficulties caused analyses of this kind to be very generally regarded with disfavor among the students of agriculture. They afford some information, but too little to meet practical demands. In recent years, chemists interested in the study of soils have attempted to devise new methods for determining what part of the plant food in soils is in a condition to be appropriated and used by crops, and these efforts have been rewarded with some measure of success. Prominent among such methods is that of acting upon the soil by means of a very weak solvent of such nature that the soil is only very slightly attacked, it being reasonable to suppose that the substances most easy to dissolve are the ones most available to the plant. Water alone does not answer the requirements as a solvent for this purpose, because water alone scarcely dissolves an appreciable amount of the phosphates in the soil which crops can use. Very dilute acids have given the best results, and the Association of Official Agricultural Chemists has provisionally adopted for this use dilute hydrochloric acid of the strength known to chemists as 1-5 normal. Such acid contains only 0.73 per cent. of pure hydrochloric acid, HCl, whereas the hydrochloric acid, of 1.115 specific gravity, already mentioned, contains 20.7 per cent., or twenty-nine times as much. In this laboratory we have been using for several years 1-5 normal nitric acid, designated in our statements of analyses as 1-5 n.HNO_3, which attacks the soil somewhat less strongly than the 1-5 normal hydrochloric acid. Our experience with Kentucky soils and crops leads to the belief that the quantities of phosphorus and potassium extracted from a soil by this solvent afford quite a good measure of the amounts of these substances that are in condition to be used by crops,

under good tillage and favorable weather conditions. In other words, this method gives a very good estimate of the "available" mineral plant food in the soil, and it is so used in our work. It is not claimed that this method is absolutely accurate or will work equally well with all types of soil; it is more properly comparative. Thus, if we have a productive soil and a poor one, both of the same type, an analysis of this kind will be of the greatest assistance in determining whether to apply phosphates or potash salts, or both, in an attempt to increase the productiveness of the poorer soil. This method applies only to the mineral plant food. As yet our method for determining the availability of the nitrogen compounds contained in the organic matter of the soil have not been sufficiently worked out, although we are able to determine nitrates and ammonia with great accuracy. Our determinations are always of total nitrogen except in a few instances where otherwise specified. They give only a very imperfect idea of how much of that substance may be "available", but they serve also the other useful purpose of giving a basis for comparing the relative amounts of organic matter in soils, for which purpose the usual "humus determinations" are very unsatisfactory. (See the third article in this Bulletin).

The percentages of "available" plant foods shown by these analyses may seem at first glance too small to be of any consequence. But if small, they are by no means insignificant, as may be seen by calculating how many pounds to the acre these percentages represent. To do this, it is necessary to estimate the weight of soil on an acre in the depth represented by the sample analyzed. These estimates will vary greatly according as the soil is light or heavy, recently worked or compacted, but for purposes of comparison we may assume 1,500,000 lbs. in the first six inches, a convenient round number, too high for ground in good tilth but about right for our bluegrass pastures. Taking as an example the first analysis under Boone County, No. 14398 we find the "Phosphoric acid dissolved by 1-5 n.HNO_3" .0009 per cent. and the "Potash dissolved by 1-5 n.HNO_3 .0062 per cent. Now .0009 per cent. of one and a half million pounds is 13½ pounds or about as much as is con-

tained in 100 lbs. of low grade acid phosphate and .0062 per cent of a million and a half pounds is 93 pounds, nearly the quantity contained in 200 lbs of commercial sulphate of potash. The figures have assumed proportions that are more easily dealt with by the practical man. A farmer who is accustomed to the use of fertilizers will recognize 100 lbs. of acid phosphate as a light dressing and 200 lbs. of potash salt as quite a liberal application. Clearly if that is all this soil is capable of supplying, it is in greater need of phosphate than of potash salts. But when we compare this analysis with those of known rich soils, we find it deficient in every important particular and therefore suggest the desirability of general building up. The percentages of "Phosphoric acid dissolved by HCl, 1.115 specific gravity", .076 per cent. and "Potash dissolved by the same", .206 per cent. reveal the presence of a reserve of plant food and give us good hope that in this process of general building up we may not have to rely entirely upon commercial fertilizers for phosphorus and potassium. These percentages, calculated into pounds per acre, amount to 1140 and 3090 pounds, respectively; enough for many a crop, if they could be made available. And it is now pretty well established that the presence of an abundance of organic matter and lime in the soil, under proper tillage, greatly increases the availability of the phosphates and probably, also, of the potassium compounds.

The analyses of subsoils not only show what supply of mineral plant food exists there but, by comparison with their top soils, afford additional means of judging the effects of cultivation. In our soils generally, especially in the best of them, the percentages of easily soluble phosphorus and potassiun compounds and of total nitrogen are comparatively small in the subsoil. The cream of the soil is at the top. Where these percentages are nearly as small in the first six inches of soil as in the second six, a depleted condition is indicated.

Space does not permit here a more extended discussion of the purposes and practical uses of soil analyses. The analyses in this Bulletin are sbmitted in the hope that they may be of assistance

not only to the senders of the samples analyzed, but also to their neighbors and to many others in this State who are intelligently at work upon problems connected with soil fertility.

2. ANALYSES OF SOILS IN 1904 AND 1905.

The following pages contain analyses of 127 samples of soil from Boone, Boyd, Casey, Christian, Clark, Fayette, Gallatin, Garrard, Grayson, Green, Hardin, Henry, Knox, Logan, Muhlenburg, Nelson, Ohio, Pendleton, Rockcastle, Shelby, Trigg, Warren and Woodford Counties, arranged alphabetically by counties. These samples were not chosen with reference to the systematic examination of any stated areas or kinds of soil, most of them having been collected as occasion required in connection with some local question of the use of fertilizers or improvement of the land, but it is believed that many of them will be of general interest.

Two such local investigations, undertaken in Clark and Woodford Counties, treating respectively of the partial failure of tobacco and of clover on certain fields, are of particular value to the farmers of the Blue Grass region, besides furnishing good examples of the practical value of chemical analyses of the soil, while the analyses of samples from Fayette County, since most of these are from the Station Farm, should interest the readers of our Station Bulletins on field experiments.

The analyses of soils from Boyd, Casey, Christian, Grayson, Green, Hardin, Logan, Knox, Muhlenberg, Ohio, Rockcastle, Trigg and Warren Counties will be of interest to the farmers of the greater part of the State outside of the Bluegrass. These counties belong to the less favored region where the supply of phosphate in the soil is moderate or small and where, consequently, commercial fertilizers are extensively used. Here, also, the percentages of nitrogen, organic matter and lime are generally lower than in the bluegrass soils. Whenever the per cent. of nitrogen in such soils is found to be less than 0.2 it is a good indication that the soil would be greatly benefited by increasing its organic matter, either by the use of manure or by growing leguminuous crops, such as cowpeas and the clovers,

aided by the application of phosphate and, perhaps, also lime, preferably on some preceeding crop. In the bluegrass soils, they being quite clayey and very well supplied with phosphate, it is desirable that the per cent of nitrogen should be well above 0.2 or near 0 3 and it is not usually necessary to apply phosphates, but more often potash salts are beneficial.

Unfortunately, it is on just such soils as are low in nitrogen and organic matter and have become depleted of their easily soluble or available phosphates, potash compounds and carbonate of lime, one or all, that clovers fail and the farmer is deprived of this means for their restoration. It would seem necessary, in such cases, to resort to some strong-growing plant, like cowpeas, and the use of appropriate mineral fertilizers, until the land is brought into such condition that clover can again be grown, unless, as is seldom the case, enough manure can be had to accomplish the same end. Here let us insist upon the importance of saving and returning promptly to the land all the manure that is produced upon the farm. This is an old subject but none the less deserving of attention and not always systematically handled by our farmers.

BOONE COUNTY.

14398—Surface soil sent by Walter Crigler, Hebron, Boone County, September 8, 1903. The sample was taken "from different parts of a field that has been repeatedly tended in corn until it is very poor. The forest trees that were cleared off of it many years ago were chiefly beech with some oak. It is a clay soil with a yellow clay subsoil and lies tolerably flat." Soil light brown.

14623—Surface soil sent by John J. Rucker, Constance, Boone County, Ky., September 28, 1904. A brown soil, rather loose in texture.

ANALYSES OF THE MOISTURE-FREE SOILS—PER CENT.

Number	14398	14623
Organic and volatile matter	3.95	4.535
Nitrogen	.09	.086
Nitrogen of nitrates	——	.0005

Sand, &c., insoluble in HCl, 1.115 sp. gr.	86.98	——
Phosphoric acid dissolved by same	.076	——
Potash dissolved by same	.206	——
Phosphoric acid dissolved by 1-5 n.HNO3	.0009	.0015
Potash dissolved by same	.0062	.0114
Lime dissolved by same	.120	.190
Magnesia dissolved by same	.040	.044
Acidity as CaO, Hopkins method	——	.0035

These soils are deficient in available phosphoric acid and too low in nitrogen and organic matter. Available potash is present in fair amount in 14623, but is lower than is desirable in 14398. One of the soils is slightly acid. Phosphatic fertilizers would be beneficial on both, and perhaps a light application of lime would be desirable, especially in preparation for leguminous crops. Provision should be made for increasing the organic matter and nitrogen, either by manure or by a proper rotation of crops.

BOYD COUNTY.

14401—Soil sent by J. M. Kirker & Co., Catlettsburg, Boyd County, Ky., February 12, 1904. The sample was taken from below the sod on the highest point in a field which it is proposed to plant in corn and potatoes. It is thought to be fairly representative of the whole place. Sample a rather light brown, very friable soil.

ANALYSIS OF THE MOISTURE-FREE SOIL—PER CENT.

Organic and volatile matter	3.97
Nitrogen	.104
Sand, &c., insoluble in HCl, 1.115 sp. gr.	90.78
Phosphoric acid dissolved by same	.064
Potash dissolved by same	.130
Phosphoric acid dissolved by 1-5 n.HNO3	.0034
Potash dissolved by same	.0050
Lime dissolved by same	.135
Magnesia dissolved by same	.032

The analysis shows that this soil is poor in all the more important elements of plant food, inclusive of lime. A complete fertilizer is indicated for spring crops. For wheat, phosphate alone might answer, but for legumes both phosphate and potash

should be used. An application of marl would probably be beneficial, for the purpose of correcting the apparent tendency to acidity.

CASEY COUNTY.

14407—Soil sent by C. Bastin, Yosemite, Casey County, Ky., February 29, 1904, from his farm near that place. The land is creek bottom and produces ordinarily ten bushels of corn to the acre. The sample was taken from an average place. Mr. Bastin writes that the subsoil is a white clay and the underlying rock is "pencil and slate". He wants to know what fertilizer the soil needs for growing corn. The sample was a nearly white soil containing a few pices of weathered chert. It looks like a black slate soil

ANALYSIS OF THE MOISTURE-FREE SOIL—PER CENT.

Organic and volatile matters	4.752
Nitrogen	.126
Sand and insoluble in HCl, 1.115 sp. gr.	86.049
Phosphoric acid dissolved by same	.058
Potash dissolved by same	.542
Phosphoric acid dissolved by 1-5 n. HNO_3	.0003
Potash dissolved by same	.0126
Lime dissolved by same	.110
Magnesia dissolved by same	.036

The soil was distinctly acid to litmus paper.

The analysis shows that this soil is very deficient in phosphoric acid, and any crop grown upon it would be benefited by phosphates. It contains only moderate amounts of nitrogen and available potash, so that spring crops had best receive a complete fertilizer. An application of marl or lime should be beneficial. The land might be improved by growing upon it some leguminous crop with the aid of phosphates and lime or marl. It is deficient in vegetable matter or humus.

CHRISTIAN COUNTY.

14839—Top soil, taken three or four inches deep, from a bare spot in a clover field on the farm of J. B. Walker, five miles south-west of Hopkinsville, Ky., September, 1905. The clover

had been sown on wheat, but after the wheat was cut, nearly all the clover died. The field was in corn before the wheat. The land is upland with red clay subsoil, on the St. Louis limestone. It is light and easy to work. Ordinary yields are 40 to 50 bushels of corn per acre; 15 to 20 bushels of wheat; 800 to 1200 pounds of tobacco. Characteristic natural growth; red oak with undergrowth of dogwood and hazel. This field has been in cultivation about sixty years.

ANALYSIS OF THE MOISTURE-FREE SOIL--PER CENT.

Organic and volatile matter	3.730
Nitrogen	.102
Phosphoric acid dissolved by 1-5 n.HNO3	.0040
Potash dissolved by same	.0101
Lime dissolved by same	.116
Magnesia dissolved by same	.024
Acidity, Hopkins' method, as CaO	.0022

The soil is deficient in phosphate and low in organic matter, nitrogen, potash and lime. It is probably that a general enriching would be required to make this soil produce clover as well as formerly.

CLARK COUNTY.

Two samples of soil were analyzed from the "Indian Old Fields," a remarkable, nearly level area of several thousand acres of very rich, black soil, in the eastern part of Clark County. The samples were collected by R. R. Marshall near Indian Fields Station on the L. & E. Railroad, and are averages of the first 6 inches, taken from several places.

14411—From a cultivated field. Soil chocolate colored, nearly black when wet. The 2-mm. sieve removed 1.7 per cent. of cherty-looking gravel containing a little phosphate rock. The ½-mm. sieve removed 3. per cent. of gravel.

14412—Virgin soil from a fence row. Like 14411 in appearance. The 2-mm. sieve removed 3.4 per cent. of worn sandstone fragments and a little black slate. The ½-mm. sieve removed 5. per cent. of gravel.

Analyses of the Moisture-Free Soil—Per Cent.

	Cultivated soil.	Virgin soil.
Number	14411	14412
Organic and volatile matter	10.589	12.560
Sand, &c, insoluble in HCl, 1.115 sp. g	71.379	67.586
Ferric oxide	8.058	8.981
Alumina	6.395	6.774
Lime	.500	.600
Magnesia	.480	.500
Potash	.710	.732
Phosphoric acid	.377	.455
Titanic acid	.140	.090
Total	98.628	98.278
Total potash, J. L. Smith's method	1.61	1.62
" soda " " "	.34	.32
Nitrogen	.295	.384
Phosphoric acid dissolved by 1-5 n. HNO_3	.0069	.0234
Potash dissolved by same	.0342	.0650
Lime dissolved by same	.470	.640
Magnesia dissolved by same	.092	.132
Humus, corrected by 10 per cent. of residue	4.54	4.78

These soils are remarkably rich in all the important constituents; exceptionally so in organic matter. In phosphates and potash they equal the rich soils of the central bluegrass region about Lexington. The effect of cultivation is very apparent, especially in the smaller amounts of the important constituents dissolved by the dilute nitric acid. If these lands are sufficiently well drained, of which the writer is not informed, they should be very productive of all kinds of crops. Those who desire to raise alfalfa on this land will doubtless succeed if the drainage is good and the land well prepared.

The three samples next following were taken from a tobacco field on the farm of Stanley Prewitt in Clark County, near Tebb's Station on the C. & O. Railroad. This field of about 15 acres is situated on the Combs Ferry pike opposite the residence of John Battaille. The field was plowed from clover in the spring of 1904 and put in tobacco, the planting having been done by machine without serious interruption, and the ground all appeared to be in good condition. The plants started off

well, but in a few weeks those on one side of the field, in an area of about 5 acres, stopped growing and the crop on this part was an almost total failure, while the rest of the field made a good crop. As the rows ran across this area, the trouble was evidently not caused by differences in planting or plants. However, toward one end of the bad part about 10 or 12 rows which had been planted with rather large plants of "stand up" Burley, raised on another farm, produced good tobacco throughout their whole length, thus forming a belt of good tobacco running through the bad and enclosing a nearly rectangular area on which the crop was a failure. During the past nine years the field had been cultivated in a three-year rotation of tobacco, wheat or rye, and clover, before which period the land had probably been in small grain and clover. However, in 1898 the larger part of the field was in hemp instead of tobacco, and only the 5 acres on which the crop failed in 1904 was then in tobacco. All the earlier crops of tobacco or hemp, grain and clover, had been good all over the field except that the clover on the part where the tobacco failed in 1904 had been almost entirely frozen out in the winter of 1903-4. A series of samples was collected from the good part and a corresponding one from the bad part after the tobacco had been cut, and about two weeks later, after the field had been sown in wheat, samples were collected from the belt where the "stand up" Burley plants had made good tobacco on the poor side. The samples were taken October 1 and November 16, 1904, by A. M. Peter, using a sampling tube, who also collected the other samples from the vicinity for comparison, at the times of these two visits. Thanks are due Messrs. Prewitt and Hill for assistance in the investigation.

In tabulating these analyses it has been thought best to tabulate the top soils together for better comparison, because it is in these that the most important differences will be noted. All weights and percentages are calculated on the moisture-free samples.

14610—Average of the first six inches, Collected October 1, 1904, from the east or good side of the line dividing the good from the bad tobacco in Mr. Prewitt's field on the Combs Ferry

pike. Six cores taken by sampling tube 10 or 15 yards apart, in a straight line at right angles to the rows, parallel with the line of division between the good and bad tobacco and about 5 yards from it. The 2 mm. sieve removed 0.5 per cent. consisting of iron gravel with one or two pieces of phosphatic limestone. The total weight of soil in the first 6 inches, calculated from the weight of the sample, 6 cores, 6 inches deep, is 1,487,000 lbs. the weight of the sifted soil, 1,479,000 lbs.

14613—Average of the first 6 inches collected October 1, 1904, from the west or bad side of the same field from 6 places in a line parallel to that of the first set and about 10 yards from it. There was no perceptible difference in the appearance of this soil from the preceeding sample. The 2 mm. sieve removed 1.1 per cent. of iron gravel with a few pieces of chert and phosphate rock. Total weight of soil per acre, 1,406,000 lbs.; sifted soil 1,391,000 lbs.

14654—Average of the first 6 inches, collected November 16, 1904, from the part of the same field planted with "stand up" Burley plants which produced a belt of good tobacco near one end of the bad part. The sample was taken with a tube from 10 places about 5 yards apart in a nearly square area some 40 or 50 yards from where the two preceeding were obtained. The ground had been plowed and sown in wheat which was well up and looking best on the part of the field where the tobacco failed. This sample was like the other two in appearance. The 2mm. sieve removed 0.2 per cent. of gravel. Total weight per acre, 1,305,000 lbs.; weight of sifted soil 1,302,000 lbs. The recent preparation of the ground for sowing wheat explains why this sample was so much lighter than the other two.

14618—Average of first 6 inches, collected October 1, 1904, from a bluegrass pasture on Mr. Prewitt's farm some distance from the tobacco field already described but not far from the corn field described under No. 14616. The sample consisted of 6 cores taken about 5 yards apart in the line of an old fence row which was grown up with young hackberry trees, showing that it had not been cultivated within at least 20 years. The ground is a nearly level piece near a pond and apparently higher than

the corn field. The 2 mm. sieve removed 1.3 per cent. of gravel with a few small fragments of chert and phosphatic limestone. Total weight per acre 1,573,000 lbs.; weight of sifted soil 1,553,000.

Analyses of the Moisture-Free Soils—First 6 Inches—Per Cent.

	Good Tobacco	Tobacco Failed	Good Tobacco	Old Pasture
Number	14610	14613	14654	14618
Organic and volatile matter	7.800	7.963	7.624	9.481
Ferric oxide	4.965	4.814	4.298	4.588
Alumina	7.700	8.110	6.137	7.950
Lime	.725	1.100	.712	1.175
Magnesia	.280	.240	.400	.320
Phosphoric acid	1.335	1.755	.855	1.695
Potash	.549	.646	.375	.638
Sand, &c., insoluble in HCl, 1,115 sp. gr.	76.361	75.143	78.304	73.566
Total	99.712	99.771	98.636	99.965
Total nitrogen	.228	.238	.258	.308
Nitrogen of nitrites	.00002	.00001	.00005	.00018
Nitrogen of nitrates	.00036	.00300	.00130	.00040
P_2O_5 dissolved by 1-5 n.HNO_3	.5552	.7768	.2030	.8520
K_2O dissolved by same	.0097	.0016	.0221	.0323
CaO dissolved by same	.700	.870	.333	.940
MgO dissolved by same	.048	.032	.024	.060
Acidity as CaO, Hopkins' method	.0022	.0022	.0034	.0022
Weight of dry soil per acre, first 6 inches, lbs.	1,487,000.	1,406,000.	1,305,000.	1,553,000.

The low solubility of the potash in dilute acid where the soil failed to produce a crop of tobacco suggests that the reason for the failure was the lack of available potash, and it appears that the strip of land where the "stand up" Burley plants made a good growth was better supplied with available potash than the soil where the ordinary Burley plants grew well, so the remarkable difference was probably not due to the difference in the plants but rather to the difference in the soil. The effect of the large amount of nitrate was evident in the better growth of

wheat where the tobacco failed. The amount of phosphates is remarkably large, 1.755 per cent P_2O_5 being the highest yet observed in a Kentucky soil.

Samples of the subsoil were taken from this field and the analyses are grouped in the following table. It will be seen that they do not show the marked differences that appear in the top soil.

14611—Average of the second 6 inches, 6 cores, from the same holes as 14610, Mr. Prewitt's tobacco field, good side. The 2-mm. sieve removed 0.5 per cent. of cherty gravel. Calculated total weight of soil in the second 6 inches, per acre, 1,686,000. lbs.; weight of sifted soil, 1,677,000. lbs.

14612—Average of the second 12 inches, 3 cores only, from each alternate hole of those from which 14610 and 14611 were obtained. The 2-mm. sieve removed 0.8 per cent. of iron gravel. Calculated total weight of the second 12 inches on 1 acre, 3,850,000. lbs.; weight of sifted soil, 3,820,000. lbs.

14614—Average of second 6 inches, 6 cores, from the same holes as 14613, Mr. Prewitt's tobacco field, where the tobacco failed. The 2-mm. sieve removed 0.6 per cent. of iron gravel and cherty fragments. Calculated total weight of soil in the second 6 inches on 1 acre, 1,631,000. lbs.; weight of sifted soil, 1,622,000. lbs.

14615—Average of the second 12 inches, 3 cores only, from alternate holes of those from which 14612 and 14614 were taken. The 2-mm. sieve removed 0.8 per cent of iron gravel. Calculated total weight per acre, 3,724,000. lbs.; weight of sifted soil, 3,694,000. lbs.

14655—Average of the second 6 inches, 10 cores, from the same holes as 14654. The 2-mm. sieve removed 0.6 per cent. of gravel. Calculated total weight per acre, 1,595,000. lbs.; weight of sifted soil, 1,586,000. lbs.

14619—Average of the second 6 inches, 6 cores, from the same holes as 14618, Mr. Prewitt's pasture. The 2-mm. sieve removed 0.8 per cent. iron gravel and sandy fragments. Calculated total weight of soil per acre, 1,661,000 lbs.; weight of sifted soil, 1,646,000 lbs.

ANALYSES OF THE MOISTURE-FREE SUBSOILS. PER CENT.

	GOOD TOBACCO. Second 6 ins.	TOBACCO. Second 12 ins.	TOBACCO FAILED. Second 6 ins.	FAILED. Second 12 ins.	GOOD TOBACCO. Second 6 ins.	PASTURE Second 6 ins.
Number	14611	14612	14614	14615	14655	14619
Organic and volatile matter	6.365	5.751	6.260	5.464	5.885	7.264
Total nitrogen	.158	.102	.106	.104	.162	.207
Nitrogen of nitrites	trace	none	trace	trace	.00002	.00001
Nitrogen of nitrates	.00015	.00005	.00060	.00030	.00025	.00016
P_2O_5 dissolved by 1-5 n. HNO_3	.6952	.7652	.8120	.7984	.1800	.7820
K_2O dissolved by same	.0007	.0009	.0017	.0011	.0092	.0208
CaO dissolved by same	.860	.850	.790	.800	.375	.930
MgO dissolved by same	.032	.024	.056	.040	.020	.064
Acidity as CaO, Hopkins method	.0022	.0011	.0022	.0011	.0022	.0011
Weight of soil per acre, lbs.	1,686,000.	3,850,000.	1,631,600.	3,724,000.	1,595,000.	1,661,000

14648—Average of the first 6 inches, 10 cores, from an old fence row near the west side of the same pasture in which 14618 and 14619 were collected, on the Boone's Ferry pike, near the residence of Mrs. Steele on the south and W. Y. Jones toward the west. This line was formerly the boundary between the farms of S. T. Tevis and Roger Jones and has not been plowed for a great many years. There are hackberry trees a foot thick standing in it, and one locust tree and several locust stumps a foot or more thick. This point is some 300 yards west of the place where samples 14618 and 14619 were taken and about the same level, being near the top of the hill. Several large pieces of chert were noticed here and in other parts of this pasture. The 2-mm. sieve removed 2. per cent., consisting of fragments of chert, iron gravel, and one white quartz pebble about ½ inch in diameter. Estimated total weight of soil in 1 acre, 6 inches deep, 1,501,000. lbs.; sifted soil, 1,471,000. lbs.

14616—Average of the first 6 inches, 6 cores collected October 1, 1904, from Mr Prewitt's corn field on the Basin Spring pike, opposite the Geo. O. Tebbs residence. This field has been a long time in cultivation by Mr. Prewitt and is in fine condition. The present crop of corn is estimated at 15 bbls. per acre. The part of the field where the sample was collected is at a lower level than the pasture, No. 14618. The 2-mm. sieve removed 5.2 per cent. of iron gravel, fragments of chert and one or two fragments of phosphatic limestone. Total weight per acre, 1,423,000 lbs.; weight of sifted soil, 1,349,000 lbs.

14650—Average of the first 6 inches, 10 cores, collected November 16, 1904 from another tobacco field of Mr. Prewitt, formerly a part of the S. S. Tevis land. This field is north of the pasture and adjoins it near where sample 14648 was taken and is estimated to be 10 or 12 feet higher than that point, being at the top of the hill. The land was plowed from sod in the Spring of 1904 and produced a good crop of tobacco, estimated about 1800 lbs. per acre. The ground had not been disturbed when the sample was taken. The 2-mm sieve removed 0.3 per cent. Calculated total weight per acre, 1,452,000 lbs.; weight of sifted soil, 1,447,000 lbs.

14652—Average of the first 6 inches, 10 cores, collected November 16, 1904 from the tobacco field of W. Y. Jones adjoining and to the west of Mr. Prewitt's tobacco field just described, 14650, and about the same level or slightly lower. This is the third crop of tobacco on this field in a rotation with rye and clover which gives two crops of tobacco every five years. The crop of tobacco this year was not very good, there having been many scattered patches of ten or a dozen plants that made only a small growth. The sample was taken from these places, going across the field from Mr. Prewitt's fence towards Mr. Jones' house. The field had been sown in wheat and the spots where the tobacco had not grown well appeared greener and had made a better growth than the rest of the field. The 2-mm. sieve removed 0.7 per cent. Calculated total weight on one acre, 1,409,000 lbs.; weight of sifted soil, 1,399,000 lbs.

ANALYSES OF THE MOISTURE-FREE SOILS, 1ST 6 INCHES. PER CENT.

	Old Pasture.	Good Corn.	Good Tobacco.	Poor Tobacco.
Number	14648	14616	14650	14652
Organic and volatile matter	9.195	7.274	6.545	7.854
Ferric oxide	4.373	4.286	4.449	4.411
Alumina	5.172	5.950	7.529	6.344
Lime	.739	.350	.607	.739
Magnesia	.420	.200	.520	.480
Phosphoric acid	.485	.710	.512	.755
Potash	.455	.407	.407	.401
Sand, &c., insol. in HCl, 1.115 sp. gr	79.855	80.373	79.855	78.274
Total	99.965	99.550	100.454	99.658
Total nitrogen	.322	.226	.200	.242
Nitrogen of nitrites	.00010	.00002	.00002	.00016
Nitrogen of nitrates	.00170	.00020	.00060	.00200
P2O5 dissolved by 1-5 n.HNO3	.0720	.1150	.0380	.1400
K2O dissolved by same	.0881	.0119	.0210	.0253
CaO dissolved by same	.491	.410	.301	.470
MgO dissolved by same	.068	.056	.032	.048
Acidity, as CaO, Hopkins meth.	.0045	.0023	.0022	.0022
Weight of soil per acre, first 6 inches, lbs	1,501,000.	1,423,000.	1,452,000.	1,409,000.

The analyses do not show why the tobacco in Mr. Jones' field should not have done as well as that in the adjoining field of Mr. Prewitt. The two analyses are much alike, the difference existing being in favor of Mr. Jones' field. The larger proportion of nitrate where the tobacco was poor is to be noted here, as before, and the effect of this upon the wheat was very apparent.

The corresponding subsoils were collected and analyzed as follows:

14649—Average of the second 6 inches, 10 cores, from the same holes as 14648, Mr. Prewitt's pasture, west side. The 2-mm. sieve removed 0.9 per cent. Calculated total weight of soil per acre, 1,632,000 lbs.; weight of sifted soil, 1,617,000 lbs.

14617—Average of the second 6 inches, 6 cores, from the same holes as 14616, Mr. Prewitt's corn field. The 2-mm. sieve removed 4 per cent. of iron gravel and some cherty and sandy fragments. Calculated total weight per acre, 1,718,000 lbs.; weight of sifted soil, 1,649,000 lbs.

14651—Average of the second 6 inches, 10 cores, from the same holes as 14650, Mr. Prewitt's second tobacco field. The 2-mm. sieve removed 0.3 per cent. Calculated total weight of soil per acre, 1,774,000 lbs.; weight of sifted soil, 1,769,000 lbs.

14653—Average of the second 6 inches, 10 cores, from the same holes as 14652, Mr. Jones' tobacco field. The 2-mm. sieve removed 0.8 per cent. Calculated total weight of soil per acre, 1,671,000 lbs.; weight of sifted soil, 1,658,000 lbs.

ANALYSES OF THE MOISTURE-FREE SUBSOILS--PER CENT.

	Pasture	Corn Field	Tobacco Field	Tobacco Field
Number	14649	14617	14651	14653
Organic and volatile matter	5.612	6.285	5.267	5.878
Total nitrogen	.147	.188	.124	.158
Nitrogen of nitrites	.00001	trace	.00002	.00002
Nitrogen of nitrates	.00080	trace	.00010	.00060
P_2O_5 dissolved by 1-5 n.HNO_3	.0380	.1270	.0460	.1800
K_2O dissolved by same	.0649	.0067	.0125	.0126
CaO dissolved by same	.264	.450	.259	.486
MgO dissolved by same	.048	.048	.028	.036
Acidity as CaO, Hopkins method	.0022	.0022	.0011	.0011
Weight of soil per acre, 6 ins., lbs	1,632,000	1,718,000	1,774,000	1,671,000

Two soils from the farm of O. S. Johnson, Clark County, Ky., about five miles north of Winchester, on the Winchester and Paris pike. These samples were taken from a field that had been in tobacco in 1903 and 1904. In the spring of 1903 the field was plowed for tobacco after having been in sod six years. Before that the land had been in tobacco two years followed by rye and clover. The samples were collected by A. M. Peter and S. D. Averitt, November 18, 1904, using a sampling tube. In this field there were a few rows of very poor tobacco, the remainder being good, and the samples were taken to determine if chemical analysis would show any cause for this difference.

14730—Average of the first 6 inches, 10 cores, from the poor row through the good. A brown, rich-looking soil, distinctly acid to litmus paper.

14731—Average of the first 6 inches, 10 cores, from the good rows, taken mostly on the south side of the poor row and in a line parallel to it. Similar to the preceding in appearance and acidity.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14730	14731
Organic and volatile matter	9.774	9.953
Nitrogen	.324	.332
Phosphoric acid dissolved by 1-5 n.HNO_3	.0520	.0525
Potash dissolved by same	.0226	.0189
Lime	.533	.518
Magnesia	.048	.044

The analyses are practically identical and do not suggest a cause for the difference in the tobacco. This difference in growth was probably due to other conditions, such as faulty plowing at this point or bad setting.

The four samples next described were collected by C. R. White, Winchester, Ky., in February 1905, from his farm in Clark County, 1¼ miles north east of Wade's Mill and 8 miles from Winchester. The samples are from a rectangular field which was in tobacco in 1903, the greater part of which produced a good crop, while about one-half acre, occupying an irregular triangular shape in the north-west corner, was a failure.

At the time of sampling, the field was in rye and was to be sown with clover in the spring. The land is rolling upland with walnut and red oak timber and some white oak. It was cleared in the winter of 1896-7 and planted with tobacco in the Spring of 1897. This was followed by wheat and clover. It was put in tobacco again in the Spring of 1900, followed again by wheat and clover. The clover was cut for hay in 1902 and the seed crop saved in the fall. The sod was plowed in March, 1903 for the third planting in tobacco. The soil was deep, loose and worked nicely and was in fine condition when the tobacco was planted and there was no apparent reason for the failure on part of the ground. No fertilizers had been used on this field. Wheat was sown after the tobacco, but was winterkilled and hemp was sown in the Spring of 1904 producing a fine crop.

14735—Average of the first 6 inches, 12 cores of sampling tube, from the part of the field that produced good tobacco in 1903. A good-looking, brown soil, slightly acid to litmus paper.

14736—Average of the second 6 inches, 12 cores from the same holes as 14735. Like that sample in appearance and slightly acid to litmus paper.

14737—Average of the first 6 inches, 12 cores from the part of the field that failed to produce tobacco in 1903. Like 14735 in appearance and slightly acid to litmus paper.

14738—Average of the second 6 inches, 12 cores from the same holes as 14837. Like that sample in appearance and slightly acid to litmus paper.

Analyses of the Moisture-Free Soils-Per Cent.

	TOBACCO GOOD		TOBACCO FAILED	
	First 6 Ins.	Second 6 Ins.	First 6 Ins.	Second 6Ins
Number	14735	14736	14737	14738
Organic and volatile matter	7.968	6.504	8.101	6.263
Nitrogen	.280	.200	.292	.190
Phosphoric acid dissolved by 1-5 n.HNO_3	.0063	.0016	.0028	.0016
Potash dissolved by same	.0316	.0206	.0314	.0198
Lime	.375	.333	.343	.311
Magnesia	.036	.028	.036	.032

The soil where the tobacco failed contains less available phosphate in the first 6 inches than the rest, and this is suggested as the probable cause of the failure. This locality is at or near the top of the Winchester limestone and the poorer soil may therefore be derived from the Eden shales. All of these samples are lower in phosphate than is usual with the soil of the more central bluegrass country.

The two samples next following were collected by Mr. White for the purpose of demonstrating the difference between two kinds of soil found in that vicinity, one of which produces a poor quality of tobacco while the other produces tobacco of good quality. It seems probable that these two kinds of soil have had a different origin geologically, the poorer being derived from rocks of the lower Cincinnatian, probably the Eden shales, and the richer from the Winchester limestone.

14743—Average of the first 6 inches, 12 cores of the sampling tube, from a woodland pasture, never cultivated on Mr. C. R. White's home place, 1¼ miles northeast of Wades Mill, Ky., collected by him in February, 1905. This is known as "black walnut land" and is considered fine corn land but does not produce tobacco of good quality, even when new. The usual yields are 12 barrels of corn, 20 bushels of wheat or 1500 to 1800 pounds of tobacco per acre. The soil is black with tough yellow clay subsoil. It is slow to dry out in the Spring and stands drouth well. The forest growth is black walnut with some sugar maple and red oak. Sorrel and broom sedge are apt to grow on this land.

14744—Average of the first 6 inches, 12 cores, from a woodland bluegrass pasture, never cultivated, at Mt. Carmel Church on Stoner Creek, one-half mile west of Wade's Mill, collected by Mr. White in February, 1905. This is good tobacco, wheat and grass land, producing tobacco of good quality. The usual yields are 12 barrels of corn, 25 bushels of wheat or 1,500 to 2,000 pounds of tobacco per acre. The soil is red with a yellow clay subsoil. It does not hold moisture well and crops suffer more in a dry season than on 14745. They mature a week or ten days earlier on this land. The forest growth is bur oak, sugar maple, ash and white oak.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

	Poor Tobacco soil.	Good Tobacco soil.
Number	14743	14744
Organic and volatile matter	9.975	9.080
Nitrogen	.326	.290
Phosphoric acid dissolved by 1-5 n. HNO_3	.0020	.0158
Potash dissolved by same	.0433	.0565
Lime dissolved by same	.459	.422
Magnesia dissolved by same	.032	.036

The difference in the amounts of available phosphate in the two samples is very marked, the soil producing good tobacco having much more than the other, as was found to be the case with Nos. 14735 and 14737 where the two kinds were in the same field. The liberal use of phosphates on the poorer soil is indicated for all crops, and it is probable also that moderate liming would be beneficial on the old land.

FAYETTE COUNTY.

Two samples of soil from the land recently purchased by the Lexington Waterworks Company, formerly the Preston property, on the Richmond turnpike, about 2½ miles nearly southeast of Lexington. This land is situated, geologically, upon an outlier of the Cincinnatian (Hudson) formation, giving a narrow strip of comparatively poor land which crosses the county running nearly northeast and southwest. It was formerly known as "the beech ridge" from the prevalence of beeches, but these trees have now entirely disappeared. The soil of this strip, though of fair quality, compares very unfavorably with the superior bluegrass lands composing the greater part of Fayette County. The samples were sent by Alex. Pearson, President of the Water Company, in March, 1904.

14408—Top soil from high ground near the old house. Sample taken about 4 inches in depth from three or four different places. This is supposed to be the poorer of the two. It is a yellowish red clay. It is acid to litmus paper.

14409—Top soil from a point nearer the reservoir. Sample taken about 4 inches in depth from one place. This is supposed

to be the richer soil. A brown, sticky soil. It is alkaline to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14408	14409
Organic and volatile matter	5.090	5.050
Nitrogen	.143	.150
Sand, &c., insoluble in HCl, 1.115 sp. gr.	83.549	83.916
Phosphoric acid dissolved by same	.132	.182
Potash dissolved by same	.360	.576
Phosphoric acid dissolved by 1-5 n-HNO_3	.0005	.0217
Potash dissolved by same	.0158	.0231
Lime dissolved by same	.147	.504
Magnesia dissolved by same	.036	.056
Acidity, Hopkins' method, as CaO	.0056	alkaline

The analyses show that No. 14408 is deficient in available phosphoric acid and low in lime and both are low in nitrogen. No. 14408 is also decidedly acid.

14498—Average of the first 6 inches from the farm of Charles Gentry, Athens, Ky., in Fayette County, about two miles east of that place, eleven from Lexington, and about two miles off the Chilesburg and Cleveland turnpike. Sample sent by Mr. Gentry, May 9th, 1904. It is a dark brown, loamy soil, very slightly acid to litmus paper.

14577—Soil from the farm of Mr. G. W. Lingenfelter in Fayette County, about 7½ or 8 miles east of Lexington, on the Haley turnpike. Sample sent by Mr. Lingenfelter in September, 1904. A brown, rich-looking soil.

ANALYSES OF THE AIR-DRIED SOILS. PER CENT.

Number	14498	14577
Organic and volatile matter	6.465	4.890
Nitrogen	.191	.110
Sand, &c., insoluble in HCl, 1.115 sp. gr.	82.562	80.450
Phosphoric acid dissolved by same	.524	.302
Potash dissolved by same	.417	.582
Phosphoric acid dissolved by 1-5 n.HNO_3	.1114	.0084
Potash dissolved by same	.0324	.0092
Lime dissolved by same	.345	.315
Magnesia dissolved by same	.020	.063
Acidity, Hopkins' method, as CaO	.0022	——

No. 14498 is well supplied with the important constituents, though the nitrogen and, consequently, the organic matter and also the lime are lower than is found in the best soils of this type. No. 14577 shows a marked deficiency in nitrogen and organic matter and is correspondingly low in available phosphates and potash. It is probable that if the organic matter were increased by manuring or otherwise, the phosphates and perhaps the potash compounds also would become more available.

Soils of the Experiment Station Farm.

The three samples next described are from the acre devoted to experiments with fertilizers on wheat on the old farm of the Experiment Station, the results of which have been published in the earlier wheat bulletins of the Station. This acre (Acre C) was planted with wheat year after year, beginning in the fall of 1888, and each plot received the same kind of fertilizer each season. At the time the samples were taken the ground had become unproductive, the last crop being a failure, and the plots that had never received any fertilizer were almost bare. The samples were collected by J. N. Harper, No. 11148 on May 15, the others on May 30, 1902, and represent an average of the first 6 inches.

11148—Acre C, Plot 5; received 150 lbs. dried blood or 160 lbs. nitrate of soda per acre each year.

14490—Acre C, Plot 4; received muriate of potash at the rate of 160 lbs. per acre each year.

14491—Acre C, Plot 6; received no fertilizer.

14492—Acre C, Plot 9; received muriate of potash at the rate of 160 lbs. per acre, and either dried blood, 150 lbs., or nitrate of soda, 160 lbs., per acre each year.

Analyses of the Moisture-Free Soils. Per Cent.

Elements supplied in the fertilizer.....	N.	K.	Nothing.	KN.
Number	11148	14490	14491	14492
Organic and volatile matter	6.54	6.770	6.870	6.674
Sand, &c., insol. in HCl, 1.115 sp. gr.....	——	81.114	80.738	81.494
Ferric oxide.....	——	2.378	3.230	3.550
Alumina	——	7.352	7.170	6.860
Lime	——	.400	.475	.400

Magnesia	——	.400	.520	.400
Potash	——	.405	.400	.380
Phosphoric acid	——	.450	.444	.390
Total		99.269	99.847	100.148
Nitrogen	.182	.184	.183	.181
Phosphoric acid dissolved by 1-5 n. HNO_3	.0341	.0470	.0304	.0236
Potash dissolved by same	.0087	.0182	.0095	.0149
Lime dissolved by same	.244	.235	.255	.230
Magnesia dissolved by same	.030	.024	.032	.040

The amount of easily soluble potash obtained from the soil of the plots that received no potash is not as small as was expected, nor that from the ones that received potash fertilizers as large, though the difference between the soil which received potash salts and that which received none is quite marked. It was to be expected that the soil of Plot 5 would contain less available potash than that of Plot 6. The difference actually shown is very slight. The nitrogenous fertilizer used on Plots 5 and 9 appears not to have affected the percentage of nitrogen in those soils.

The three samples next described are from the new farm of the Experiment Station. The field sampled was an old pasture and it is not known how long it has been in bluegrass. No doubt it was formerly cultivated in the usual farm crops. It is all high ground. The samples were collected in April, 1902, by J. N. Harper and A. M. Peter, at which time the sod had just been broken for tobacco. It is a typical bluegrass soil with sticky red clay subsoil containing iron gravel.

14493—Average of the first 6 inches taken from several places in the plots laid out for the soil experiment in co-operation with C. C Moore, Jr. of the Bureau of Chemistry, U. S. Department of Agriculture. Red soil typical in appearance.

14494—Average of the first 6 inches from several places in another part of the same field where tobacco is to be planted. The soil is typical in appearance and the sample was taken to represent the tobacco field.

14495—Average of the first 6 inches from several places in a shallow depression or basin in the same field, from which there

is no surface drainage though situated on high ground. The soil in this depression is black, probably from deficient drainage. This point is near where No. 14494 was taken and the contrast is very marked between the black soil here and the red of the rest of the field. When dry, this soil has an ashen gray color.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

	RED SOIL	RED SOIL	BLACK SOIL
Number	14493	14494	14495
Organic and volatile matter	6.690	6.640	7.302
Sand etc. insoluble in HCl, 1.115 sp. gr.	80.745	80.640	80.986
Ferric oxide	3.830	3.798	2.946
Alumina	6.488	6.942	6.604
Lime	.600	.650	.725
Magnesia	.480	.480	.420
Potash	.410	.407	.452
Phosphoric acid	.562	.590	.770
Total	99.805	100.147	100.205
Nitrogen	.196	.194	.245
Phosphoric acid dissol' by 1-5 n. HNO3..	.1102	.1238	.3002
Potash	.0103	.0096	.0162
Lime	.392	.410	.400
Magnesia	.036	.032	.024

The analyses of the two samples of red soil are good duplicates, as they should be from their situation in the field. They show lower percentages of nitrogen and easily soluble potash than would be expected from pasture land that has never been cultivated, which is in agreement with the presumption that this land was a long time in cultivation before it was made a pasture. The fact that the soil had been recently turned probably caused more than the just proportion of the subsoil to be taken in the sample, thus lowering the apparent availability of the potash. The black soil is materially richer in the important elements than the red, probably the effect of washing. The high solubility of the phosphates in this soil is noteworthy.

The next two samples are of the same type of soil as No. 14493 and 14494 but from a different part of the Station farm. They were collected November 24, 1904, from the field used for an experiment with fertilizers on tobacco. This land was for-

merly a garden. The same variety was planted on both plots known as "twist bud Burley".

14772—Average of the first 6 inches, 12 cores, from "Plot 1" which received no fertilizers. The tobacco grown on this plot was not nearly as good as that on "Check C", next to be described, being about the poorest in the field.

14773—Average of the first 6 inches from "Check C," which received no fertilizer. The tobacco on this plot was very much better than that on "Plot 1" (14772).

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

	Poor Tobacco.	Good Tobacco.
Number	14772	14773
Organic and volatile matter	6.025	7.952
Nitrogen	.204	.292
Phosphoric acid dissolved by 1-5 n.HNO_3	.1270	.1410
Potash	.0459	.0574
Lime	.412	.508
Magnesia	.052	.052

The analyses do not show a deficiency in any of the essentials, though all are lower in 14772, where the tobacco was not very good, than in 14773. The difference in nitrogen is very marked, implying a correspondingly large difference in the amount of organic matter, and it seems probable that the presence of enough organic matter in 14773 to give it a better physical condition was an important factor in producing the better crop on that plot.

The next 18 samples are from the plots at the Station farm devoted to forage plant investigations by Prof. Garman in co-operation with the U. S. Department of Agriculture, including the series for rotation of crops. The samples are averages of the first 6 inches, 12 cores of the sampling tube each, collected November 25 and 26, 1904. The samples were taken for the purpose of testing whether the effect of growing legumes as compared with grasses or tobacco could be traced in the analyses. The analyses show such a lack of uniformity in the soil of the several plots examined, that a discussion of them with refer-

ence to this point would hardly lead to any definite conclusions at this time. It is proposed, however, to analyze the soil of these same plots again from time to time, whereby it may be possible to detect any considerable changes.

14768—From Plot No. 1. In English bluegrass continuously since 1902. This is a 1-80 acre plot, 24 x 22.7 feet, as are also the next three, Nos. 6, 11 and 124.

14769—From Plot 6. In soy bean in 1904. This plot lies between No. 1 and No. 11, being separated from them only by a 3-foot path.

14770—From plot No. 11. In Kentucky bluegrass since 1902.

14771—From Plot No. 124. This was in red clover in 1902 and 1903 and soy bean in 1904. This plot is about 280 feet from No. 11 and 28 feet from the end of Plot No. 150 (14796).

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Plot and crop	1 English bluegrass.	6 Soy bean.	11 Kentucky bluegrass.	124 Clover and soy bean.
Number	14768	14769	14770	14771
Organic and volatile matter	6.703	6.502	6.693	8.004
Nitrogen	.200	.242	.234	.294
Phosphoric acid dis. by 1-5 n.HNO3	.0880	.0865	.0855	.1125
Potash dissolved by same	.0516	.0612	.532	.0423
Lime dissolved by same	.470	.412	.319	.503
Magnesia dissolved by same	.064	.048	.048	.036

The soil of Plot No. 124 seems to have been originally richer than that of the other three plots, as shown by the phosphoric acid, and a larger percentage of nitrogen was to be expected here, without considering what may have been added by the clover and soy bean crops. The other plots show a distinct advantage in favor of the soy bean plot, No. 6, amounting to 120 pounds of nitrogen to the acre more than is contained in the soil of the Kentucky bluegrass plot. As already remarked, however, it will require a series of analyses during a term of years to enable us to trace such gains with certainty.

The next 14 samples are from the crop rotation experiments. These plots are 24 x 90.75 feet, being an area of 1-20 acre.

They are laid out in two tiers of 13 plots each, so that the end of No. 161 is opposite to the end of No. 148, that of 162 to 149, and so on, the plots being separated by a pathway. It is important to note the relative position of the plots in comparing the analyses.

14807—From Plot 161. In tobacco in 1902, oats in 1903, timothy in 1904, and, when sampled, November 26, 1904, had recently been prepared and sown again.

14808—From plot 162 In oats in 1902, timothy in 1903 and 1904 and had recently been plowed and sown in wheat which was just coming up at the time of sampling.

14761—From plot 163. In soy bean in 1902, wheat in 1902-3 tobacco in 1904. Manure had been used for the tobacco. At the time of sampling, the ground had not been plowed. The weight of tobacco produced on this plot in 1904 was the least of all the plots that year.

14809—From plot 164. In wheat 1902-3, tobacco 1904, with manure. Had not been plowed when sampled.

14810—From plot 165. In tobacco 1902, oats 1903, soy bean in 1904. Had not been plowed at time of sampling. Manure had been used on some of the crops.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Plot	161	162	163	164	165
Number	14807	14808	14761	14809	14810
Organic and volatile matter	7.444	6.444	6.368	6.541	7.198
Nitrogen	.214	.195	.184	.194	.224
Phosphoric acid dissolved by 1-5 n. HNO_3	.0468	.0300	.0325	.0320	.0576
Potash dissolved by same	.0338	.0221	.0179	.0251	.0371
Lime dissolved by same	.328	.318	.264	.291	.334
Magnesia dissolved by same	.044	.036	.032	.040	.036

There is a slight rise in the ground about Plot 163, and it is interesting to note how the soil increases in richness down the gentle slope to either side. The writer has often noted examples of this sort. The effect seems to be due to the gradual removal

of the best soil immediately at the surface of the higher points, leaving exposed more and more of the subsoil with its lower percentages of available plant food. The variation in the percentage of phosphoric acid in our bluegrass soils is not always due to this cause, however, as will be pointed out presently.

14760—From Plot 148. In red clover and orchard grass in 1902 and 1903, tobacco in 1904, and had been prepared and sown in wheat, which was well up at the time of sampling. The weight of tobacco produced on this plot in 1904 was the largest of all that year.

14795—From Plot 149. In tobacco in 1902, wheat 1902-3, oats 1904, manured, plowed and sown in grass a short time before the sample was taken.

14796—From Plot 150. In orchard grass 1902, 1903 and 1904, and there was a good growth on the plot when the sample was taken.

14797—From Plot 152. In oats 1902, then manured with 2 to 3 tons of manure, timothy 1903 and 1904, of which there was a fine sod on the plot when sampled.

14798—From Plot 153. In red clover and orchard grass in 1902 and 1903, tobacco in 1904. The ground had not been plowed at the time of sampling.

14799—From Plot 154. In tobacco 1902 and 1903, oats 1904, then 2 to 3 tons of manure plowed in and timothy sown. The grass had not come up when the sample was taken.

14800—From Plot 156. In tobacco 1902, followed by barley, and the same in 1903; oats 1904, then manure turned under and grass sown, which was just coming up at the time of sampling.

14805—From plot 158. In red clover and orchard grass in 1902 and 1903, wheat in 1904. The ground had not been plowed when sampled.

14806—From plot 154. In wheat in 1902 and 1903, tobacco, 1904. The ground had not been plowed when sampled.

Analyses of the Moisture-Free Soils--Per Cent.

Plot	148	149	150	152	153	154	156	158	159
Number	14760	14795	14796	14797	14798	14799	14800	14805	14806
Organic and volatile matter	7.132	7.255	7.275	7.000	7.330	6.997	7.563	9.229	8.313
Nitrogen	.238	.264	.236	.232	.240	.230	.238	.290	.264
Phosphoric acid dissolved by I-5 n. HNO_3	.0595	.0476	.0470	.0488	.0618	.0710	.0892	.2464	.1898
Potash dissolved by same	.0248	.0360	.0349	.0375	.0453	.0397	.0450	.0489	.0431
Lime dissolved by same	.343	.329	.322	.277	.343	.333	.314	.609	.541
Magnesia dissolved by same	.048	.048	.036	.036	.028	.032	.028	.044	.032

A comparison of analysis No. 16761 with No. 14760 shows smaller percentages of essentials in the soil producing the poorer crop, as was noted in analyses 14772 and 14773. In this case, however, the per cent. of nitrogen and, consequently, of organic matter in the poorer soil is considerably less than is desirable.

The great differences in phosphoric acid here shown, as, for example, between .0892 in plot 156 and .2464 in plot 158, only 30 feet away, are not unusual in those of our bluegrass soils that are situated, like these, in the phosphatic horizon at the top of the Lexington limestone. In such situations the soil has been formed from the weathering down of limestone strata in which quite rich phosphatic layers occur. One can readily see that the soil formed at the outcropping of a rich phosphatic layer might be very much richer than that nearby which had come from less phosphatic beds. Other examples af great variations of this kind in the proportion of phosphoric acid will be found under Clark and Woodford counties.

14482—Top soil from one of Prof. Garman's plots that was in soy bean in 1901, inoculated with Dr. Hiltner's culture of root nodule bacteria. Sample collected by T. L. Richmond, May 5, 1902. The 2-mm. sieve removed 1 per cent. of the air-dried sample, consisting of iron gravel with some chert and phosphate. The ½-mm. sieve removed 5 per cent. of gravel from the soil which had passed the 2 mm. sieve.

14883—Top soil from a corresponding plot which was in soy bean in 1901 but not inoculated. Sample collected at the same time for comparison. The 2-mm. sieve removed o 6 per cent. and the ½-mm. sieve 3 per cent.

These were adjoining plots, Nos. 55 and 68, separated only by a 3-foot path.

ANALYSES OF THE MOISTURE FREE-SOILS. PER CENT.

Number	14482	14483
Organic and volatile matter	6.890	6.950
Nitrogen	.231	.219
Sand, &c., insoluble in HCl, 1.115 sp. gr.	81.778	81.321
Phosphoric acid dissolved by same	.490	.474
Potash dissolved by same	.435	.437
Phosphoric acid dissolved by 1-5 n.HNO3.	.1117	.0815
Potash dissolved by same	.0502	.0447
Lime dissolved by same	.375	.335
Magnesia dissolved by same	.028	.032

Judging by the greater availability of the phosphate in 14482 this must have been originally the richer soil, and it is impossible to say whether it gained more nitrogen from the soy beans than did the soil of the other plot.

14484—Sample of the first 9 inches of the plot used for the co-operative experiment with C. C. Moore, Jr., mentioned under 14493. This sample was obtained by cutting down the sides of the triangular hole from which the sample of earth sent to Mr. Moore had been taken. The 2-mm. sieve removed 0.6 per cent. of iron gravel from the air-dried sample, and the ½ mm. sieve removed 6 per cent. from the soil that had passed the 2-mm. sieve.

14485—Second 9 inches of 14494, obtained in the same way. The sample all passed the 2-mm. sieve and the ½-mm. sieve removed 4 per cent. of gravel.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14484	14485
Organic and volatile matter	6.210	4.330
Sand, &c., insoluble in HCl, 1.115 sp. gr.	82.546	84.201
Ferric oxide	1.668	1.100
Alumina	7.710	8.368
Lime	.300	.350
Magnesia	.220	.340
Phosphoric acid	.392	.322
Potash	.337	.347
Total	99.383	99.358
Nitrogen	.186	.098
Phosphoric acid dissolved by 1-5 n. HNO_3	.0281	.0185
Potash dissolved by same	.0096	.0073
Lime dissolved by same	.260	.210
Magnesia dissolved by same	.040	.020

A comparison with analyses Nos. 14493 and 14494, representing the first 6 inches from the same field, will serve to show how much the analysis is affected by the depth of sampling. The availability of plant food in the subsoil is usually much less than in the top soil and the nitrogen and organic matter much less. The deeper the sample is taken the less information is afforded about the plant food in the first few inches, which is to be of controlling influence in the growth of a crop. Deep sampling tends to obscure important agricultural differences.

GALLATIN COUNTY.

14310—Swamp muck sent by J. J. Payne, Sunnyside Fruit Farm, Warsaw, Gallation County, Ky., January 4, 1904. The sample was nearly dry and light and contained much partly decayed vegetable matter. It was strongly acid to litmus paper.

ANALYSIS—PER CENT.	As Received	Moisture Free
Moisture at 100°C.	15.78	——
Total Nitrogen	.99	1.18
Available nitrogen (neutral KMnO4 method)	.52	.62
Total phosphoric Acid	.22	.26
Phoshoric acid dissolved by 1-5 n. HNO3	.03	.04
Potash dissolved by same	.04	.05
Potash dissolved by water	.04	.05

This material might be used with advantage by mixing it with lime or wood ashes and applying to poor land.

GARRARD COUNTY.

Two samples were sent by Rev. F. M. Tinder, Lancaster, Ky , collected according to our directions in March, 1905. It is desired to raise potatoes and garden truck on this land.

14719—Average of the first 6 inches from several places. Brown soil, slightly acid to litmus paper.

14720—Sample of the second 6 inches from one spot. Somewhat lighter colored than the top soil and slightly acid to litmus paper.

14856—Soil sent by J. E. Robinson, Lancaster, Ky., September 14, 1905, from a field which had been in corn in 1902, 1903 and 1904 and in millet in 1905 and is to be sown in wheat and timothy, with clover in the Spring. The sample was taken from 4 places, about 8 or 10 inches deep after removing about an inch on the surface. Soil yellowish brown.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Number	14719	14720	14856
Organic and volatile matter	6.033	4.741	3.730
Nitrogen	.124	.092	.102
Phosphoric acid dissolved by 1-5 n. HNO_3	.0066	.0022	.0040
Potash dissolved by same	.0242	.0094	.0101
Lime dissolved by same	.227	.185	.116
Magnesia dissolved by same	.043	.036	.024
Acidity, as CaO, Hopkins Method	——	——	.0022

These soils are much too low in nitrogen and organic matter. Liberal manuring is indicated, especially for garden truck, combined with moderate lining. Mr. Robinson should use a fertilizer containing both phosphate and potash on the wheat for the benefit of the clover to follow and might well apply some lime for the same reason.

GRAYSON COUNTY.

14838—Sent by C. McBride, Millerstown, Ky , August 25, 1905. The land is to be sown in wheat. A small sample, slightly acid to litmus paper.

ANALYSIS OF THE MOISTURE-FREE SOIL—PER CENT.

Organic and volatile matter	5.726
Nitrogen	.128
Phosphoric acid dissolved by 1-5 n.HNO_3	.0018
Potash dissolved by same	.0149
Lime dissolved by same	.196
Magnesia dissolved by same	.042

Phosphate is indicated for the wheat, but the soil is low in all the essentials and a general building up would be desirable.

GREEN COUNTY.

Soil and subsoil sent by H. H. Smith, Summersville, Ky., March 9, 1905, to determine what fertilizer his land needs.

14721—Average of the first 6 inches, taken according to our directions. A light brown soil, slightly acid to litmus paper.

14722—Sample of the second 6 inches taken from one place only. A light reddish color, very faintly acid to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS—PER CENT.

Number	14721	14722
Organic and volatile matter	3.358	3.597
Nitrogen	.076	.046
Phosphoric acid dissolved by 1-5 n.HNO3	.0007	trace
Potash dissolved by same	.0088	.0106
Lime dissolved by same	.084	.053
Magnesia dissolved by same	.024	.036

This soil is very deficient in phosphates and poor in nitrogen, organic matter, potash and lime.

HARDIN COUNTY.

Three samples of soil from the farm of M. R. Gardner, three miles west of Sonora, Hardin County, Ky. These samples were collected by Mr. Gardner according to directions sent from the Station.

14745—Average of the first 6 inches from a field in cultivation 10 years, now in grass. A light-brown soil, slightly acid to litmus paper.

14746—Average of the first 6 inches, from a field in cultivation 100 years, now in corn. A reddish-brown soil, slightly acid to litmus paper.

14747—Sample of the second 6 inches of No. 14746 from one place only. A reddish soil, slightly acid to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS—PER CENT.

Number	14745	14746	14747
Organic and volatile matter	4.409	4.180	3.363
Nitrogen	.118	.114	.062
Phosphoric acid dissolved by 1-5 n.HNO3	.0007	.0007	.00015
Potash dissolved by same	.0258	.0217	.0139
Lime dissolved by same	.153	.090	.132
Magnesia dissolved by same	.024	.032	.016

The analyses show these soils to be very deficient in phosphoric acid and low in nitrogen. They are very well supplied with potash. They are also low in lime, especially No. 14746. The greatest deficiency is in phosphoric acid.

14836—Average of the first 6 inches from a cornfield on the farm of John D. Miller, Glendale, Ky., 12 miles south of Eliza-

bethtown and 2½ miles west of Nolin Station. This is rolling upland "with a good deal of barren rock on the hillsides." In a good season it will produce 12 to 20 bushels of wheat per acre, or 40 bushels of corn. For the past four years it has been impossible to get a good growth of clover on this land. A good stand was obtained, but in August the tops died. Mr. Miller has been using the Cleveland Dryer Co.'s XXX Phosphate for the past seven years.

14835—Average of the second 6 inches of 14836. Sample buff colored.

Analyses of the Moisture-Free Soil--Per Cent.

Number	14836	14835
Organic and volatile matter	4.064	3.800
Nitrogen	.114	.092
Phosphoric acid dissolved by 1-5 n. HNO_3	.0008	.0007
Potash dissolved by same	.0137	.0106
Lime dissolved by same	.106	.058
Magnesia dissolved by same	.028	.020
Acidity, by litmus paper test	acid	acid

This soil is very deficient in available phosphates and low in organic matter and lime, conditions unfavorable to the growth of clover.

HENRY COUNTY.

14399—Soil brought by F. R. Crabb, Eminence, Ky., November 17, 1903, from his farm in Henry County, three miles West of that place on the Eminence and Smithfield turnpike at the edge of Shelby County. The land was in wheat in the season of 1902-3 and was in rape when the sample was taken. The sample is an average of the first 4 inches, taken from 5 or 6 different places.

The two samples following are from the farm of Newton Bright in Henry County, 1½ miles north of Eminence on the Eminence and Newcastle pike, April 11, 1904. The original timber was principally yellow beech, hickory, walnut and sugar maple. The land has been in cultivation 20 years and has had a good deal of tobacco raised on it. In 1900 it was in tobacco, producing 1200 lbs. to the acre; this was followed by wheat,

yielding 20 bushels; next it was in clover and was grazed in 1902 and 1903. The clover was plowed under in the fall of 1903 and sown in rye, of which there was a fine crop on the land at the time of sampling.

14477—Average of the first 6 inches from several different places in the field. A rich-looking, chocolate colored soil, decidedly acid to litmus paper.

14478—Sample of the second 6 inches from only one place. A yellow, sticky clay, more acid than the top soil.

ANALYSES OF THE MOISTURE-FREE SOILS—PER CENT.

Number	14399	14477	14478
Organic and volatile matter	6.09	5.200	4.380
Nitrogen	.182	.148	.055
Sand, &c., insoluble in HCl, 1.115 sp. gr.	84.99	85.220	82.227
Phosphoric acid dissolved by same	.356	.274	.274
Potash dissolved by same	.278	.300	.458
Phosphoric acid dissolved by 1-5 n.HNO3	.0688	.0182	.0094
Potash dissolved by same	.0105	.0102	.0077
Lime dissolved by same	.335	.185	.175
Magnesia dissolved by same	.044	.040	.036
Acidity, as CaO, Hopkins' method	——	.0034	.0784

The soil 14399 appears to be in better condition than 14477 as shown by the higher nitrogen, available phosphoric acid and lime, but the difference may be somewhat exagerated by the fact that the former soil was taken to a depth of only 4 inches. Both these soils are well supplied with phosphates and fairly so as to potash, though the amonnt of the latter available is not quite as large as is desirable. In 14477 there is a tendencely towards acidity, shown more strongly in the subsoil, which is decidedly acid. Moderate lining is suggested, especially as a preparation for clover or other leguminous crop. The amount of organic matter and nitrogen should be increased, either by manuring or by a proper rotation with leguminous crops.

14732—Soil from the farm of J. M. Guthrie, New Castle, Henry County, Henry County, Ky., sent by him in April, 1905. A very light-brown soil, distinctly acid to litmus paper.

ANALYSIS OF THE MOISTURE-FREE SOIL—PER CENT.

Organic and volatile matters	4.874
Nitrogen	.120
Phosphoric acid dissolved by 1-5 n.HNO3	.0009
Potash dissolved by same	.0116
Lime dissolved by same	.137
Magnesia dissolved by same	.040

The analysis shows a soil poor in all the important constituents of fertilizers, but especially deficient in phosphates.

KNOX COUNTY.

Three samples of soil from the grounds of St. John's Academy in Knox County, Ky., within the corporate limits of Corbin and one-half mile east of Lynn Camp Creek which runs through that town and is the boundary between Knox and Whitley Counties. This ground is not known to have ever been cultivated. The samples were sent by Wm. M. Washington, Principal of the Academy, October 28, 1904, and were taken according to our directions.

14633—Average sample of top soil, taken to the depth of six inches from several places. This is a gray, rather sandy-looking soil, containing some pieces of coal and cinders and parts of plants of finger grass and sour dock.

14634—Subsoil of the same, being the second 6 inches, taken from one spot. A light brown, almost gray soil containing some plant roots.

14635—Average sample of the first 6 inches at a place where the original surface soil has been covered up by filling in with subsoil brought from another place. This is a buff-colored, cloddy soil.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

KIND OF SOIL	NATURAL Top Soil	NATURAL Subsoil	FILLED Top Soil
Number	14633	14634	14635
Organic and volatile matter	3.510	3.215	1.720
Nitrogen	.086	.074	.018
Sand, &c., insoluble in HCl, 1.115 sp. gr.	92.469	——	93.458
Phosphoric acid dissolved by same	.042	——	.018
Potash dissolved by same	.125	——	.191

Phosphoric acid dissolved by 1-5 n. HNO3..	.0023	.0034	.0005
Potash dissolved by same	.0054	.0040	.0036
Lime dissolved by same	.042	.026	.021
Magnesia dissolved by same	.008	.010	.004
Acidity as CaO, Hopkins method	.0308	.0157	.1389

These soils are poor in all the important constituents of fertilizers, but especially in phosphates. They are decidedly acid and deficient in lime. Crops would not produce satisfactorily upon them without the aid of a complete fertilizer and a sufficient application of lime, marl or wood ashes to neutralize the acid. Estimating the weight of soil on an acre of 6 inches depth of the natural top soil at 1¾ million pounds and that of the same depth of subsoil at 2 million pounds, the amounts of quick lime required, calculated from the analyses, would be :—for No. 14633, 540 lbs per acre; for No. 14634, 196 lbs., and for No. 14635, 1736 lbs. To improve this land with the least possible outlay for commercial fertilizers, the growing of leguminous crops upon them, with the aid of phosphate and lime, or the liberal use of stable or barn yard manure, with lime and phosphate, is suggested.

LOGAN COUNTY.

14834—Average sample taken 6 to 10 inches deep from several places on the farm of R. E. Youmans, Adairville, Ky., 6 miles north-east of that place and 4 miles east of Oakville on the O. & N. division of the L. & N. R. R. The land is gently rolling upland with red subsoil and has been in cultivation 50 or 60 years. It produces 10 bushels wheat and 20 bushels corn and there is difficultiy getting a stand of clover. The sample was collected by Mr. Youmans, August, 1905, according to our directions.

ANALYSIS OF THE MOISTURE-FREE SOIL--PER CENT.

Organic and volatile matter	3.818
Nitrogen	.166
Phosphoric acid dissolved by 1-5 n. HNO3	.0022
Potash dissolved by same	.0143
Lime dissolved by same	148
Magnesia dissolved by same	.020
Acidity to litmus paper test	slight

The soil is deficient in available phosphate and low in organic matter and lime, all unfavorable conditions for the growth of clover.

MUHLENBERG COUNTY.

Two samples of soil sent by Samuel J. Landes, Greenville, Muhlenberg County, Ky., November 12, 1904. The samples were taken from a woodland in which almost all of the finest trees have died, apparently from the effect of water from coal mines. According to Mr. Landes, there are thousands of trees 3 to 4 feet in diameter on the land that have died since the water was turned on.

14636—Average sample of the top soil, taken to the depth of 6 inches from several places. A brownish gray, rather sandy-looking soil. All passed the 2-mm. sieve.

14637—Subsoil of the same representing the second 6 inches in depth, taken from one spot. A buff-colored, cloddy soil, apparently containing much fine sand. All passed the 2mm. sieve.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT

Number	14636	14637
Organic and volatile matter	6.415	4.500
Total nitrogen	.154	.048
Nitrogen of nitrites	none	none
Nitrogen of nitrates	.0003	none
Sand, &c., insoluble in HCl, 1.115 sp. gr.	80.327	——
Phosphoric acid dissolved by same	.120	——
Potash dissolved by same	.483	——
Phosphoric acid dissolved by 1-5 n.HNO_3	.0029	.0010
Potash dissolved by same	.0142	.0085
Lime dissolved by same	.100	.085
Magnesia dissolved by same	.040	.044
Sulphuric acid dissolved by same	.004	trace
Acidity as CaO, Hopkins method	.627	.0650
Chlorides	a trace	a trace

This soil is decidedly acid and deficient in lime, but since the amount of sulphuric acid present is very small, it is hardly proved that the acidity is due to the water from the coal mines, which would be likely to contain a very considerable amount of

sulphates, especially ferrous sulphate or copperas. In fact, a test for copperas, applied to the water extract of the soil, gave a negative result.

The analyses indicate that this land is capable of being made productive, if favorably situated. The first step in this direction would be to correct the acidity by the application of lime or of calcareous marl or wood ashes. After this the land might be planted in some leguminous crop, such as cow peas, soy beans, or clover, &c., grown with the aid of commercial phosphates to supply the deficiency in phosphoric acid.

Two other samples of soil from Muhlenberg County, Ky., were sent by Mr. Landes, Greenville, Ky., December 23, 1904, in continuation of the same investigation. (See 14636–7).

14679—Labeled, "Not affected by the copperas water from the coal mines." A light-colored, almost gray soil. The 2-mm. sieve removed only a few pieces of roots, bark, &c.

14680—Labeled, "From three of the worst places affected by the copperas water." The sample was red like fresh iron rust, but on breaking some of the clods it was found that the iron was on the outside, the inside of the clods being gray. This sample was very wet and sticky. The 2-mm. sieve removed some pieces of coal, rotten sandstone, roots, bark, &c.

Both samples were wet when received; No. 14679 was found to contain 20 per cent. water, and No. 14680, 33.7 per cent.

Both samples were decidedly acid, but water extracts of each, made from the soils before drying, did not show any material quantity of copperas. It was apparent, however, that the red iron rust in 14680 had been formed by the decomposition of the copperas on coming in contact with the soil, at the same time being exposed to the air. These water extracts of the two samples were found to be quite different; that from 14679 was neutral and only contained very little matter in solution, whereas that from 14680 was decidedly acid and contained notable quantities of the sulphates of aluminium, manganese, calcium and magnesium. Analyses of these solutions gave the following results calculated as per cents. of the dry soil.

Number	14679	14680
Acidity, calculated as lime required to neutralize	none	.0160
Ferric oxide	.0005	.0005
Alumina		.0031
Manganous oxide		.0072
Lime	.0020	.0512
Magnesia	.0008	.0151
Silica	.0021	.0058
Sulphuric anhydride	.0024	.1296
Total fixed matter	.0085	.2000

The weight of soil on an acre of ground, taken 6 inches deep, is between 1½ and 2 million pounds. Taking the lower figure, the weight of aluminium sulphate in the soil of an acre like 14680, to the depth of 6 inches, would be 150 lbs. of the dry salt. The soil at greater depths may contain as much or more. This certainly is enough to prove injurious to vegetation, but the fact that the copperas that is decomposed in the soil acts like an acid, must be taken into consideration over and above the action of this aluminium sulphate.

The following determinations were made upon the dried soils to further compare the effect of the copperas water.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Number	14679	14680
Phosphoric acid dissolved by 1-5 n. HNO_3	.0006	.0445
Potash dissolved by same	.0135	.0125
Lime dissolved by same	.0792	.0686
Magnesia dissolved by same	.0320	.0300
Ferric oxide and alumina	.3114	2.0495
Organic and volatile matter	5.453	13.615
Nitrogen	.1200	.1490
Acidity, as lime required to neutralize	.2016	.3315

The increased amount of iron oxide shown in 14680, above that in 14679, has presumably been derived in large part from the decomposition of copperas in the mine water after coming into contact with the soil and air; the acid of the coperas has also acted upon the soil itself, bringing the phosphates and probably some of the iron oxide and alumina into more soluble forms than they were in the unaffected soil. If it were not for the acid condition, this increased solubility of valuable constituents would

temporarily increase the fertility of the soil, but, under the existing conditions, it only tends to increase the waste of fertility by leaching.

The fertility of these soils could, no doubt, be restored, as has been already suggested, by a liberal application of lime or of calcareous marl. Land like 14680 should receive 3 or 4 tons of quicklime to the acre or a larger quanity of marl, according to its quality, and on 14679, about half as much should be used. If such applications are to be made, they should be made during the winter. It would not be surprising if a better result were obtained on 14680 than on 14679.

NELSON COUNTY.

14837—Soil sent by H. McKenna, Fairfield, Ky., August 22, 1905, from his alfalfa field. This was sown in April 1904, and three cuttings had been made in 1905, the first two being good but the third not so good and the alfalfa seems to be dying. The ground was new and rich. It was sown in alfalfa in 1903 when a poor stand was obtained so it was plowed up and sown again the next year.

ANALYSIS OF THE MOISTURE-FREE SOIL--PER CENT.

Organic and volatile matter	6.205
Nitrogen	.190
Phosphoric acid dissolved by 1-5 n. HNO_3	.0248
Potash dissolved by same	.0259
Lime dissolved by same	.302
Magnesia dissolved by same	.040
Acidity as CaO, Hopkins' method	.0017

The analysis does not show any marked deficiency of mineral plant food that would account for the alfalfa dying, though the organic matter, as indicated by the per cent. of nitrogen, is lower than is desirable.

OHIO COUNTY.

14410—Average sample of the first 6 inches, sent some time ago by E. G. Austin, Prentiss, Ohio County, Ky., from one of the fields where the fertilizer experiments described in Bulletin 89, p. 181, were made. These experiments showed that potash

salts and nitrates, separately or in mixture, produced only a very slight increase in the yield of wheat, whereas acid phosphate gave a very marked increase alone and in combination and was the most profitable fertilizer tried.

ANALYSIS OF THE MOISTURE-FREE SOIL--PER CENT.

Organic and volatile matter	3.700
Ferric oxide	2.414
Alumina	3.606
Lime	.200
Magnesia	.300
Phosphoric acid	.040
Potash	.262
Titanium dioxide	.070
Total	100.036
Total potash, J. L. Smith's method	1.36
Total soda, J. L. Smith's method	.65
Total nitrogen	.075
Phosphoric acid dissolved by 1-5 n. HNO_3	.0007
Potash dissolved by same	.0154
Lime dissolved by same	.130
Magnesia dissolved by same	.060

The analysis shows that the soil is very deficient in phosphates, though fairly well supplied with available potash. The proportions of nitrogen and organic matter and lime are too low, showing the need of manuring or enrichment by means of leguminous crops grown with the aid of commercial phosphates and lime or marl. A large area of soil in our coal-measures is of this character. In Mr. Austins experiments with wheat the unfertilized plots gave an average yield of only 5¼ bushels per acre for three years. The use of 320 lbs. of acid phosphate gave an average yield of 14 bushels for the same time. Addition of nitrate of soda and potash salts caused only a slight further increase, not enough to pay the additional cost of the fertilizer.

Two samples of soil were sent by C. N. Taylor, Roxey, Ky., August 10, 1905, from his farm near that place.

14868—"No. 1. This is corn land and will be sown in wheat."

14869—Labeled, "No. 2. This is in peas and will be sown in timothy."

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14866	14869
Organic and volatile matter	4.082	4.000
Nitrogen	.142	.144
Phosphoric acid dissolved by 1-5 n.HNO3	.0009	.0008
Potash dissolved by same	.0137	.0091
Lime	.111	.090
Magnesia	.044	.032

Both soils are very deficient in available phosphate and low in the other essentials and in organic matter. A phosphatic fertilizer alone will probably give the most profitable result with wheat, but for spring crops generally a complefe fertilizer is indicated. It is likely that the timothy will need an additional supply of nitrogen which might be in the form of nitrate of soda, applied in early spring.

PENDLETON COUNTY.

14400—Soil sent by C. R. Colbert, Preston Station, Pendleton County, Ky., November 24, 1903, from his farm which adjoins the station on the west. The land is rolling creek bottom and has been in cultivation for seventy years. It is capable now of producing only about ten bushels of corn to the acre, and that does not mature well. The sample was an average, taken to the depth of six inches from eighteen different places in the field. A small sample of the subsoil from six to twelve inches was taken, but it unfortunately got mixed with the large sample through the breaking of the sack. A rather light-brown soil, apparently inclining to a sandy texture. The subsoil was more clayey and somewhat more yellowish in color.

ANALYSIS OF THE MOISTURE-FREE SOIL. PER CENT.

Organic and volatile matter	3.34
Nitrogen	.076
Sand and silicates insoluble in HCl, 1.115 sp gr	90.16
Phosphoric acid dissolved by same	.096
Potash dissolved by same	.202
Phosphoric acid dissolved by 1-5 n.HNO3	.0011
Potash dissolved by same	.0038
Lime dissolved by same	.120
Magnesia dissolved by same	.32

The analysis shows that this soil is poor in all the most important elements of plant food, inclusive of lime, and especially so in phosphates. A complete fertilizer is indicated for all spring crops; phosphate for wheat and phosphate with potash for legumes. An application of marl would probably be beneficial to correct an evident tendency to acidity.

ROCKCASTLE COUNTY.

Soil and subsoil from the farm of E. Owen, Hiatt, Rockcastle County, Ky., situated five miles north west of Mt. Vernon. The land is level, slightly rolling. The part from which the sample came has been in cultivation 16 years. It is much run down and there is much catbrier (smilax) on it and patches of sour dock. The original forest growth was principally black oak and chestnut, but at present there is mostly sassafras, persimmon, some sour wood and black gum and scattering blackberry briers.

14480—Top soil—Average sample taken to depth of 6 inches. A light brown soil slightly acid to litmus paper.

14481—Subsoil—Sample taken from one place, 6 to 12 inches deep. A yellowish colored, rather light subsoil, decidedly acid.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14480	14481
Organic and volatile matter	4.484	2.938
Nitrogen	.079	.029
Sand, &c., insoluble in HCl, 1.115 sp. gr.	84.430	88.094
Phosphoric acid dissolved by same	.038	.022
Potash dissolved by same	.180	.245
Phosphoric acid dissolved by 1-5 n-HNO_3	.0012	.0005
Potash dissolved by same	.0159	.0094
Lime dissolved by same	.125	.040
Magnesia dissolved by same	.024	.036
Acidity, as CaO, Hopkins' method	.0022	.112

The analysis shows that the soil is poor in all the important constituents of fertilizers, but especially deficient in phosphoric acid. It is also acid and would probably be benefited by marl or lime.

14499—Soil from the farm of Harvey Chenault at Conway in Rockcastle County, Ky. Average sample of surface soil, taken to the depth of 6 inches, from a field in the bottom of Roundstone Creek, just west of Conway Station. The land is level, surrounded by sandstone hills, and needs draining. The subsoil is hard and compact, but apparently rather sandy; it is light colored. The land was cleared from forest within the last few years. Last year it was in sorghum, sown with fertilizer; now it is in rye, and the rows where the fertilizer was applied last year show a much stronger growth of the rye than elsewhere. The sample was taken between the fertilized rows by Harvey Chenault and A. M. Peter, May 9, 1904.

ANALYSIS OF THE MOISTURE-FREE SOIL. PER CENT.

Organic and volatile matter	4.559
Nitrogen	.108
Sand and silicates insoluble in HCl, 1.115 sp. gr.	88.024
Phosphoric acid dissolved by same	.054
Potash dissolved by same	.350
Phosphoric acid dissolved by 1.5 n.HNO3	.0007
Potash dissolved by same	.0150
Lime dissolved by same	.085
Magnesia dissolved by same	.040
Acidity as CaO, Hopkins method	.0672

It would require 1,000 pounds of quicklime per acre to neutralize the acidity of the top soil. The analysis shows that this soil is poor in all the important constituents of fertilizers, but especially so in phosphates. It is fairly well supplied with potash.

SHELBY COUNTY.

14832—Average sample of surface soil brought by Mr. Harry Weissinger, from his farm in Shelby County, about 1½ miles south of Shelbyville, September 5, 1905. The land had been sown in wheat in the fall of 1904 and clover the following spring. After the wheat was cut the clover began to die, although it had made a good growth up to that time, and the field grew up in ragweed. A similar experience was had on this field the previous season. Specimens of the clover brought at the same time were about 6 inches high and well rooted but without root nod-

ules. No evidence of insect or fungus injury was observed, though some of the leaves were filled with irregular brown spots. These were examined under the microscope, but no fungus growth could be found.

14847—Average of the first 6 inches from the same field taken according to our directions September 14, 1905.

Analyses of the Moisture-Free Soils. Per Cent.		
Number	14832	14847
Organic and volatile matter	5.070	4.845
Nitrogen	.176	.152
Phosphoric acid dissolved by 1-5 n.HNO3	.0412	.0246
Potash dissolved by same	.0133	.0133
Lime dissolved by same	.191	.211
Acidity Hopkins' method, as CaO	.0011	.0011

The lower figures for organic and volatile matter, nitrogen, phosphoric acid and lime in the second sample are probably due to the greater depth to which that sample was taken.

The soil is lower in nitrogen and, therefore, in organic matter than should be in a good bluegrass soil. It is low, also, in potash and lime. These are unfavorable conditions and may have much to do with the failure of the clover The use of manure, lime and potash salts is suggested or the growing of cowpeas or some other strong-growing legume.

As root nodules were absent in the clover plants examined, it may be that inoculation would be beneficial here.

TRIGG COUNTY.

The seven samples following were collected by Mr. S. D. Averitt in August, 1903.

17439—Average of the first 6 inches from the farm of Mrs. D. E. Averitt, Caledonia, Ky., situated about three miles northwest of that place. The sample is from a field that has been in cultivation 40 or 50 years but was in grass at the time of sampling. The principal crops raised were tobacco, wheat, clover and corn. The soil is light brown in color and acid to litmus paper.

14740—Second 6 inches of 14739. Sample reddish colored and acid to litmus paper.

14748—Average of the first 6 inches from the farm of T. N. Wadlington, Gracey, Ky., situated in Trigg County nearly west of that place. The field sampled had been in wheat. Soil light brown colored and slightly acid to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS. PER CENT.

Number	14739	14740	14748
Organic and volatile matter	3.332	3.568	3.226
Nitrogen	.106	.082	.100
Phosphoric acid dissol' by 1-5 n. HNO3..	.0009	.0005	.0063
Potash dissolved by same	..0179	;0147	.0374
Lime dissolved by same	,153	.153	.106
Magnesia dissolved by same	.036	.032	.040

14756—Average of the first 6 inches from the farm of Bailey Matheney, Golden Pond, Ky. Sample from a cultivated field. A light brown soil, slightly acid to litmus paper.

14757—Average of the first 6 inches from the farm of Mrs. Abner Tuggle, Cadiz, Ky., about 5 miles south-east of that place. A light brown soil, acid to litmus paper.

14758—Average of the first 6 inches, from the farm of W. H. Hardy, Caledonia, Ky., situated about four miles south of that place, near Pedee. A brown soil, slightly acid to litmus paper.

14759—Average of the first 6 inches, from the farm of E. E. Wash, Wallonia, Ky. The field sampled had been in wheat. A brown soil, slightly acid to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS—PER CENT.

Number	14756	14757	14758	14759
Organic and volatile matter	3.460	3.310	3.094	3.462
Nitrogen	.096	.066	.084	.096
Phosphoric acid dis. by 1-5 n.HNO3...	.0009	.0008	.0010	.0013
Potash dissolved by same	.0167	.0155	.0204	.0204
Lime dissolved by same	.158	.064	.095	.127
Magnesia dissolved by same	.048	.040	.032	.032

All these Trigg County soils are low in nitrogen; therefore, also, in organic matter, and all except No. 14748 are very deficient in easily soluble or available phosphate. They have a fairly good supply of available potash, but are all low in lime and somewhat acid. No. 14748 is much richer in available

phosphate and potash than the others and, indeed, the analysis shows more available phosphoric acid in this than is usual in the soils of this type.

WARREN COUNTY.

Soil and subsoil from the farm of C. J. Wagner in Warren County, Ky., 3½ miles southwest of Bowling Green, on the east side of the Bowling Greeen and Russellville pike. Sample sent by Mr. J. T. Dishman, from whom Mr. Wagner recently purchased the farm. Received May 24, 1904. This is the Clarksville clay loam of the Bureau of Soils.

14509—Average sample of the top soil, taken 6 inches deep from several places. A reddish-brown soil, rather sandy in texture. It was faintly acid to litmus paper.

14510—Subsoil of the same, taken from 6 to 12 inches deep, from one spot. A bright red, rather clayey subsoil, faintly acid to litmus paper.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Number	14509	14510
Organic and volatile matter	3.695	3.905
Nitrogen	.076	.054
Sand, &c., insoluble in HCl, 1.115 sp. gr.	88.195	83.249
Phosphoric acid dissolved by same	.070	.040
Potash dissolved by same	.430	.347
Phosphoric acid dissolved by 1-5 n.HNO3	.0008	.0004
Potash dissolved by same	.0147	.0117
Lime dissolved by same	.155	.190
Magnesia dissolved by same	.036	.032
Acidity as CaO, Hopkins method	.0067	trace

This soil is very deficient in phosphates and is poor also in organic matter and nitrogen as well as in lime. It contains a fairly good supply of potash. The acidity is very slight.

Two samples of soil sent by J. E. Williams, Bowling Green, Ky., September 6, 1904, from his farm in Warren County, about 2½ miles east of that place. This is what is locally known as "burr rock" land; the subsoil is red and has "burr rock" all through it, and the land has what is called "duck nests." The samples were taken after scraping off about an inch of the top

soil. The two samples were very similar, being red brown, loamy soil.

14592--"Sample No. 1, from the highest point or top of elevation. This upland does not produce as good wheat, corn or clover as it ought to from the looks of the soil.

14593—"Sample No. 2, from the slopes where the soil seems poorer and less productive; for as you manure this, it washes down into the bottom of the "duck nests" where the soil is very rich. The soil where this sample was taken is full of small rock It is hard to get a stand of clover on this land and the corn does not make very well, as the stalks and ears are small "

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Number	14592	14593
Organic and volatile matter	3.400	3.930
Nitrogen	.090	.100
Sand, &c , insoluble in HCl, 1.115 sp. gr	89.704	87.482
Phosphoric acid dissolved by same	.046	.055
Potash dissolved by same	.188	.256
Phosphoric acid dissolved by 1-5 n.HNO3	.0009	.0005
Potash dissolved by same	.0087	.0107
Lime dissolved by same	.075	.110
Magnesia dissolved by same	.024	.032

These soils are both very deficient in phosphoric acid and phosphatic fertilizers are indicated for all crops, especially wheat and clovers. They are too low in nitrogen, available potash and lime, so that corn, tobacco, and spring crops generally should receive a complete fertilizer. The most economical method of improving this land would be by growing leguminous crops upon it with the aid of phosphatic fertilizers and lime or marl.

Two samples of soil from the farm of E. O. Grissom in Warren County, Ky., five miles south of Bowling Green, sent by J. E. Williams, September 6, 1904. This is loeally known as "limestone soil" and is of average quality, but it does not produce as it should. The land is fairly level, with enough fall to drain well. The samples were a reddish-brown, loamy soil, like Nos. 14592 and 14593. Complete data were not furnished regard-

ing these samples. This also is probably the Clarksville clay loam of the Bureau of Soils.

Analyses of the Moisture-Free Soils--Per Cent.

Number	14594	14595
Organic and volatile matter	3.860	3.175
Nitrogen	.106	.077
Sand, &c , insoluble in HCl, 1.115 sp. gr	88.176	89.526
Phosphoric acid dissolved by same	.050	.025
Potash dissolved by same	.307	.280
Phosphoric acid dissolved by 1-5 n.HNO3	.0012	.0009
Potash dissolved by same	.0169	.0162
Lime dissolved by same	.153	.143
Magnesia dissolved by same	.040	.028

The remarks under 14509 and 14510 apply equally well to these soils.

WOODFORD COUNTY.

The ten samples of soil next described are from the farm of Paul Lansing, formerly the Withrow place, in Woodford County, Ky., about two miles south-east of Midway, on South Elkhorn creek and just off the Weisenberger's mill pike. The first 6 were collected May 29 1904 by A. M. Peter and Mr. Lansing and are averages consisting of 5 or 7 cores of the sampling tube from several yards apart. The remaining four were taken in like manner by Mr. Lansing, September, 4. 1904.

14513—Average of the first 6 inches from bare spots in a clover field near and on the south side of the residence. These bare spots are scattered irregularly over this part of the field, which is on a moderate slope, and some of them are several yards across. A growth of ragweed is starting on them. Total weight of moisture free soil on one acre, 1 769,000 lbs., calculated from the weight of 5 cores taken.

14514—Average of the second 6 inches of 14513 from the same holes. Calculated total weight on one acre 1,922,000 lbs. of moisture-free soil.

14515—Average of the first 6 inches from a timothy field south-west of the residence and adjoining the clover field described

above. The timothy was sown in the fall of 1903, made only fair growth and poor stand, and yielded not over one-half ton per acre. Total weight of moisture-free soil on one acre, 1,668,000 lbs., calculated from the weight of 7 cores taken.

14516—Average of the second 6 inches of 14515 from the same holes. Calculated total weight on one acre, 1,820,000 lbs. of moisture-free soil.

14517---Average of the first 6 inches from another part of the clover field already described (No. 14513) where the clover has made a good growth. Here the ground is nearly level, being at the top of the slope and across a slight valley from where the samples 14513 and 14514 were collected.

14518 --Average of the second 6 inches of 14517, from the same holes. Calculated total weight on one acre 1,809,000 lbs., moisture-free soil.

14604---Average of the first 6 inches from the second woodland north-east of the residence. Total weight on one acre, 1,527,000 lbs. moisture-free soil, calculated from the weight of 10 cores taken. The 6 mesh sieve removed 2.3 per cent of fragmets of phosphate and chert.

14605---Average of the second 6 inches of 14604 from the same holes. Total weight on one acre, 1,663,000 lbs. moisture free soil, calculated from 10 cores taken. The 6 mesh sieve removed one per cent of gravel like that of 14604 but containing more phosphate.

14606---Average of the first 6 inches from the timothy field west of the residence. This was sown the same fall as the other field (No. 14515) and made a good crop. Total weight on 1 acre, 1,377,000 lbs of moisture-free soil. No gravel was obtained by sifting on the 6 mesh sieve.

14607 · Average of the second 6 inches of 14606, from the same holes. Total weight on one acre, 1,941,000 lbs. of moisture-free soil. The 6 mesh sieve removed only 0.2 per cent of gravel.

Analyses of the Moisture-Free Soils—Per Cent.

	CLOVER FIELD.			
	Bare Places.		Good Growth.	
Depth sampled	First 6 ins.	Second 6 ins.	First 6 ins.	Second 6 ins.
Number	14513	14514	14517	14518
Organic and volatile matter	4.575	4.335	5.856	4.227
Sand, &c., insoluble in HCl, 1.115 sp. gr.	82.033	81.212	.....	.....
Potash	.340	.448	.....	.....
Phosphoric acid	.428	.382	.....	.....
Total nitrogen	.104	.080	.156	.082
Nitrogen of nitrates	.000020	trace	none	none
Nitrogen of nitrites	.000001	.000005	.000005	.000007
Phosphoric acid dissolved by 1-5 n.HNO_3	.0346	.0212	.0586	.0384
Potash dissolved by same	.0099	.0101	.0205	.0218
Lime dissolved by same	.225	.240	.395	.270
Magnesia dissolved by same	.024	.036	.052	.040
Acidity, Hopkins method, as per cent. CaO	.0045	.0022	alkaline	.0022
Total weight of soil on 1 acre	1,769,000	1,922,000	.....	1,809,000

Analyses of the Moisture-Free Soils—Per Cent.

	Timothy Fields.				Woodland Bluegrass Pasture	
	Fair Growth.		Good Growth.			
Depth sampled	First 6 ins.	Second 6 ins.	First 6 ins.	Second 6 ins.	First 6 ins.	Second 6 ins
Number	14515	14516	14606	14607	14604	14605
Organic and volatile matter	4.985	4.503	6.210	4.880	8.365	5.695
Sand, &c , insoluble in HCl, 1.115 sp. gr.			80.896	79.460	76.174	78.422
Ferric oxide					3.891	3.644
Alumina					6.464	7.331
Lime					1.725	1.500
Magnesia					.240	.140
Potash			.472	.501	.548	.557
Phosphoric acid			.625	.755	1.385	1.425
Sulphuric acid					.113	.120
Total					99.905	98.834
Total nitrogen	.122	.090	.186	.116	.308	.158
Nitrogen of nitrates	.000750	.000100				
Nitrogen of nitrites	.000160	.000080				
Phosphoric acid dissolved by 1-5 n.HNO3	.0438	.0570	.1652	.2498	.7536	.6488
Potash dissolved by same	.0129	.0102	.0212	.0356	.0376	.0242
Lime dissolved by same	.280	.315	.325	.380	.875	.745
Magnesia dissolved by same	.032	.024	.044	.036	.048	.064
Acidity, Hopkins method, as per cent. CaO	.0022	.0022	.0034	.0022	.0034	.0011
Total weight of soil on 1 acre	1,668,000	1,820,000	1,377,000	1,940,000	1,527,000	1,663,000

A study of these analyses affords some interesting comparisons. The percentages of potash and lime dissolved by 1·5 normal nitric acid, the total nitrogen and, therefore, the organic matter, are all materially larger in the soils where clover and timothy made a good growth than in those where these crops failed to make satisfactory growths. The analysis of the sample from the woodland shows what percentages of these substances may be obtained from a very rich soil of the same type. The percentages of easily soluble phosphoric acid show the same relations, but being present in abundance in all the samples, we may leave it out of consideration, except to note that its amount is unusually large in the soil of the woodland. The only soils we have yet analyzed exceeding these percentages are from Clark County and are described in this Bulletin under that heading. The soil from the bare spots also shows marked, though small, acidity, whereas that from the good clover is alkaline. It is important to note that the first 6 inches of soil on these bare places is much heavier than that of the good timothy field or even that of the woodland pasture and is nearly the same as the second 6 inches of the good clover field. These relative weights are doubtless in great measure dependent upon the amounts of organic matter contained in the soils. It is apparent that the conditions noted are less favorable to growth in the bare spots of the clover field and in the thin timothy field than in the others and both the cause of the failure and the possible remedy are strongly suggested. Some facts in the history of these fields, before they came into Mr. Lansing's possession will be of interest here. The clover field and thin timothy field had been farmed with bad judgement and, about 7 or 8 years ago, had been plowed wet, leaving the ground in bad condition. Wheat and barley were grown upon them alternately for a long time and then clover, which was plowed under for more wheat. In the bare spots of the present clover field the wear upon the soil was increased by the situation of this part upon a slope, causing the surface soil to be more rapidly carried away by washing. The good timothy

field, however, was formerly a feed lot and pasture and, although put in cultivation several years ago, no doubt still shows the effect of the manure accumulations.

The writer is indebted to Mr. Lansing for valuable suggestions and assistance in this investigation.

3. THE DETERMINATION OF HUMUS IN SOILS.

Many determinations of humus have been made in this laboratory upon our Kentucky soils by the method of the Association of Official Agricultural Chemists, but the results have been so discordant and misleading that this determination is no longer included in our regular work on soils. In some instances discrepancies arose that were wholly unaccountable and it seemed impossible to obtain consistent duplicates from the same sample; in others, subsoils which evidently contained very little humus have given higher figures than the corresponding top soils whose color and appearance indicated its presence in larger proportion than in the subsoil and badly worn soils have given more by this method than the same type of soil in a state of good cultivation. This latter kind of discrepancy may be explained in part from the fact that the ammoniacal solution of the humus, as prepared by the official method, retains more or less clay and ferric hydrate the latter more or less perfectly dissolved. These substances are not completely dehydrated by drying at 100° C. so that whatever water they retain will be erroneously counted as humus. The writer has attempted to approximately eliminate this error by deducting from the apparent weight of humus 10 per cent of the weight of the residue remaining after burning off the humus and believes that the results thus modified are nearer the truth than without this correction. Even so, much remains to be desired in our method for determining humus.

The effect of the error referred to may be seen from the following results obtained upon a soil and subsoil belonging to the "bluegrass" type but one of the poorer varieties.

ANALYSES OF THE MOISTURE-FREE SOILS--PER CENT.

Number	14477	14478
Humus, official method	2.45	2.26
Same, less 10 per cent. of residue	1.83	.91
Humus, same solution after settling 7 days	2.17	1.61
Same, less 10 per cent. of residue	1.76	.60
Total nitrogen	.148	.055

It is not unreasonable to assume that the quantity of humus present is nearly in proportion to the per cent. of nitrogen, which would give about a third as much humus in the second 6 inches as in the first. The corrected figures approximate this relation, whereas the figures obtained by carefully following the official method would lead one to suppose that the second 6 inches was nearly as well supplied with humus as the first, a supposition not to be entertained by any one acquainted with this particular soil. It will be noted, also, that as the solution is cleared by standing, the difference between the uncorrected figures for humus in soil and subsoil becomes greater. It was found, however, that even after the solutions had stood several months and become apparently clear, they still contained a very considerable amount of ferruginous matter, presumably in solution.

To test the relative amount of humus in another way, portions of the humus solution corresponding to 1 gram of soil were oxidized by boiling with potassium permanganate solution in presence of sulphuric acid, after the method followed in water analysis. The permanganate solution used contained 3 grams of the salt to the liter. The number of cc. reduced, from the mean of two close experiments, was, for 14477, 2.65 cc., and for 14478, 0.95 cc. The same relation between the first and second 6 inches, about 3 to 1, as is shown by the nitrogen determinations, appears again here. A similar experiment was made upon 1 gram portions of the soil itself, the mean of two experiments showing,

for 14477, 17.5 cc. of permanganate reduced, and for 14478, 6.2 cc. Here, again, we have an approximation to the same ratio, although six times as much permanganate has been reduced.

Still another method was tried for comparing relative amounts of humus without weighing. By evaporating the humus solution to dryness, treating the residue repeatedly with strong nitric acid, taking up with water, filtering and making alkaline with ammonia, a clear yellow solution is obtained which can be compared colorimetrically with a standard solution of ammonium picrate, as in water analysis. While it is not claimed that a benzene residue is a constant or essential constituent of all humus, it may be fairly assumed that, in soils which have supported the same kind of vegetation for many years, the proportion of such residues will be pretty uniform, and that, therefore, the relative intensities of the colors produced will be roughly in proportion to the actual amounts of humus present. It was most convenient to express the relative intensities by the corresponding amounts of nitrogen, calculated as per cent. of the soil. This method, in addition to the ones already described, was tried upon a set of typical bluegrass soils from adjoining fields. These soils are of good quality, but have been somewhat impoverished by long cultivation and do not contain as much humus or nitrogen as the best of their class. The following is a tabulation of the results obtained :